KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

KIRKLAND PUMP STATION

TASK 310 REPORT

DECEMBER 1999

KING COUNTY
Department of Natural Resources

EXECUTIVE SUMMARY

The Conveyance System Improvement (CSI) Project involves planning efforts on an array of pump station and conveyance system improvements. The purpose of this report is to evaluate the existing Kirkland Pump Station and related conveyance system components, and identity improvements to convey the projected increasing basin flows.

The Kirkland Pump Station is located on the northwest corner of the intersection of 3rd Street and Park Lane in Downtown Kirkland and serves approximately 1,022 acres in the City of Kirkland. This pump station force main extends 3,210 feet from the pump station to the Eastside Interceptor (ESI). The pump station overflow is 300 feet upstream of the pump station near the intersection of Central Way and 3rd Street.

The most recent flow projections prepared by King County in June 1999 indicated that the 1990 pump station base flow of 0.52 million gallons per day (mgd) is projected to more than double to 1.09 mgd in 2050 as the basin is further developed. In addition, the infiltration and inflow (I/I) flows are projected to increase as a result of deterioration of the collection system. The estimated I/I in the Kirkland Pump Station Basin is relatively high, 5,200 gallons per acre-day (gpad) for the 20-year peak storm as compared to 2,280 gpad in the Juanita Bay Pump Station service area.

The Kirkland Pump Station has a number of operational problems under existing flow conditions that will only be exacerbated as flows increase to the pump station. Based on the review of the existing pump station and related conveyance system components, the three items with the greatest potential to disrupt pump station operations or otherwise compromise its ability to convey wastewater include:

- The influent sewer enters the wetwell above the normally operating water surface and is limited to 5.3 mgd without surcharging the line;
- The switchgear, MCCs, and associated electrical equipment are reportedly in need of replacement; and
- The asbestos cement pipe (ACP) section of the existing force main has reportedly failed in the past and should be replaced with an 18-inch diameter pipe.

Other recommended improvements include:

- Replacement grating in the wetwell;
- Float switches in the wetwell;
- A new flowmeter;
- Replacement electrical equipment;

- HVAC system modifications;
- Backflow prevention improvements;
- An upgraded seal water system;
- A larger capacity diesel fuel storage tank;
- Noise attenuation improvements;
- Aesthetic improvements to the pump station exterior; and
- Replacement pumps, discharge piping, and new VFDs.

The total capital cost to upgrade the pump station is $2.8 million. Approximately 84 percent of the costs to upgrade the pump are associated with realigning and upsizing the influent sewer, installing new pumps, and replacing the 14-inch ACP section of the existing force main. These improvements are recommended even if an I/I reduction program is sufficient to offset the projected deterioration of the collection system.

As flows increase to the pump station, the wetwell may experience operational conditions that adversely affect pump performance. It is not clear from comparison of the flow through the wetwell to commonly used design parameters if this will cause problems. Further analysis of the wetwell hydraulics during predesign is recommended.

CHAPTER 1 - INTRODUCTION

The Conveyance System Improvement (CSI) Project involves planning efforts on an array of pump station and conveyance system improvements. The purpose of this report is to evaluate the existing Kirkland Pump Station and related conveyance system components, and identity improvements to convey the projected increasing basin flows.

The Kirkland Pump Station is located on the northwest corner of the intersection of 3rd Street and Park Lane in Downtown Kirkland (Figure 1-1). Construction of the pump station and force main was completed in 1966 (Table 1-1). The pump station replaced a wastewater treatment plant as part of the Metro regionalization project in the 1960's. There have been some minor modifications to the pump station since it was completed including replacement of the raw sewage pumps, installation of an additional sump pump, and installation of an emergency generator.

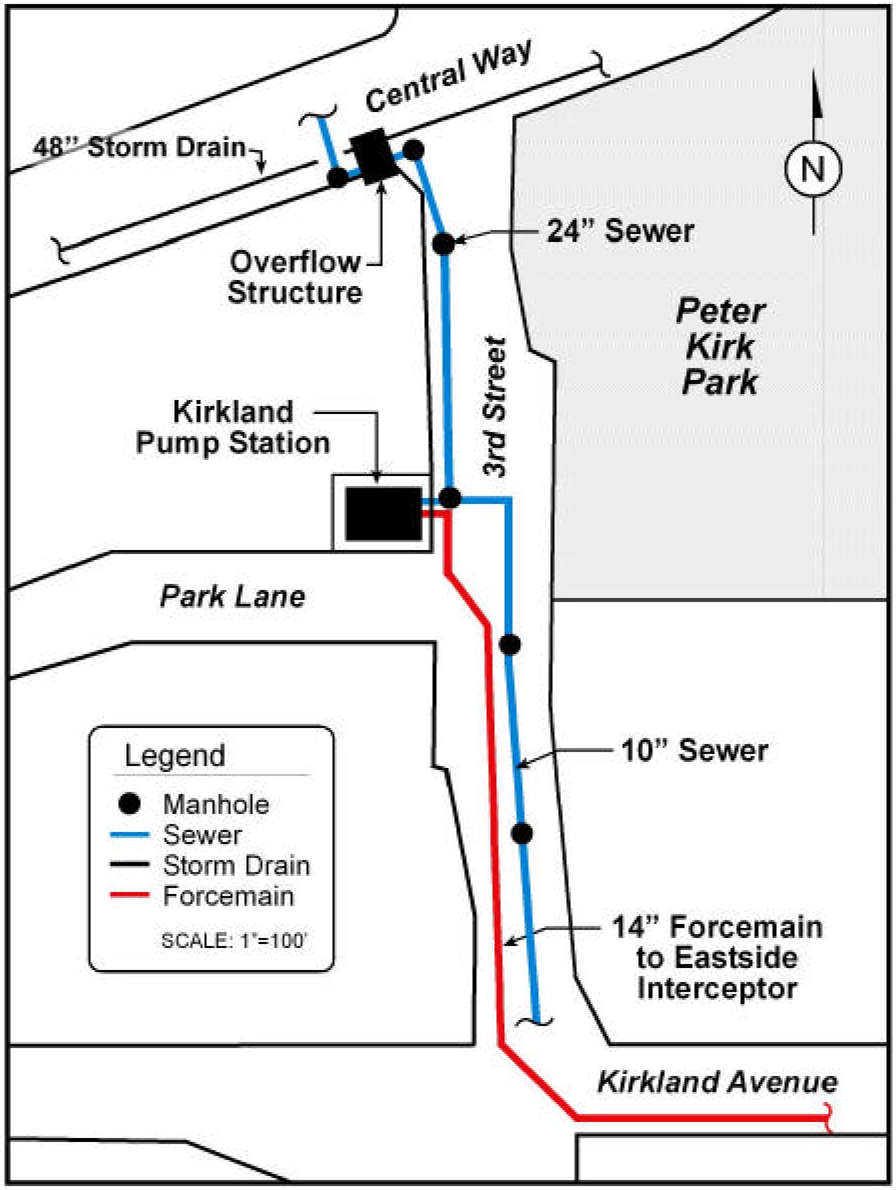
Table 1-1. Construction Information

Construction/Modification	Date Completed
Constructed Kirkland Pump Station and 14-inch force main.	1966
Replaced pumps.	1984
Installed redundant sump pump	1992
Installed emergency generator	1997

SERVICE AREA AND COLLECTION SYSTEM RELATIONSHIPS

The Kirkland Pump Station serves approximately 1,022 acres in the City of Kirkland, 981 acres of which are sewered. The main interceptors to the pump station include a 24-inch diameter pipe to the north and a 10-inch diameter pipe that serves areas to the south of the pump station. Three raw sewage pumps discharge sewage from the wetwell into a 14-inch force main. This force main extends 3,210 feet from the pump station to the Eastside Interceptor (ESI), an elevation gain of approximately 135 feet. The ESI, in turn, conveys wastewater to the South Treatment Plant in Renton.

The pump station overflow is 300 feet upstream of the pump station near the intersection of Central Way and 3rd Street. If the sewage in the overflow structure reaches elevation 123.31 feet (Metro Datum), it discharges into the 48-inch storm drain beneath Central Way. This storm drain discharges into Lake Washington. Since the raw sewage pumps were upgraded in 1986, seven overflows have been recorded: six of which were due to either mechanical failures or power outages.



KING COUNTY
Conveyance System Improvements
Kirkland Pump Station

Figure 1-1
Pump Station
Site Plan

CHAPTER 2 – FLOW PROJECTIONS

The most recent flow projections prepared by King County in June 1999 indicated that the 1990 pump station base flow of 0.52 million gallons per day (mgd) is projected to more than double to 1.09 mgd in 2050 as the basin is further developed (Table 2-1). In addition, the infiltration and inflow (I/I) flows are projected to increase to account for deterioration of the collection system. The 20-year peak flows include a 7 percent increase in I/I rates per decade up to a maximum of almost 29 percent over 1990 conditions. As a result of these projected I/I and base flow increases, the peak 20-year flow is projected to increase to 7.7 mgd by 2050, well above the nominal peak capacity of the pump station of 6.0 mgd. In addition, the year 2000 projected 5-year peak flow of 5.5 mgd exceeds the nominal firm capacity of the pump station of 5.0 mgd as shown on Figure 2-1.

Table 2-1. Flow Projections

Year	Base Flow (mgd)	5-yr I/I (gpad)	5-yr Peak (mgd)	20-yr I/I (gpad)	20-yr Peak (mgd)
1990	0.52	4,570	5.0	5,200	5.6
2000	0.72	4,900	5.5	5,580	6.2
2010	0.80	5,240	5.9	5,960	6.6
2020	0.89	5,580	6.4	6,340	7.1
2030	0.96	5,910	6.8	6,730	7.6
2050	1.09	5,910	6.9	6,730	7.7

POTENTIAL FOR I/I REDUCTION

King County is currently developing an I/I program to reduce I/I thereby reducing capital costs associated with building additional conveyance and treatment facilities as well as reducing operational costs. The estimated I/I in the Kirkland Pump Station Basin is relatively high, 5,200 gallons per acre-day (gpad) for the 20-year peak storm as compared to 2,280 gpad for the Juanita Bay Pump Station service area.

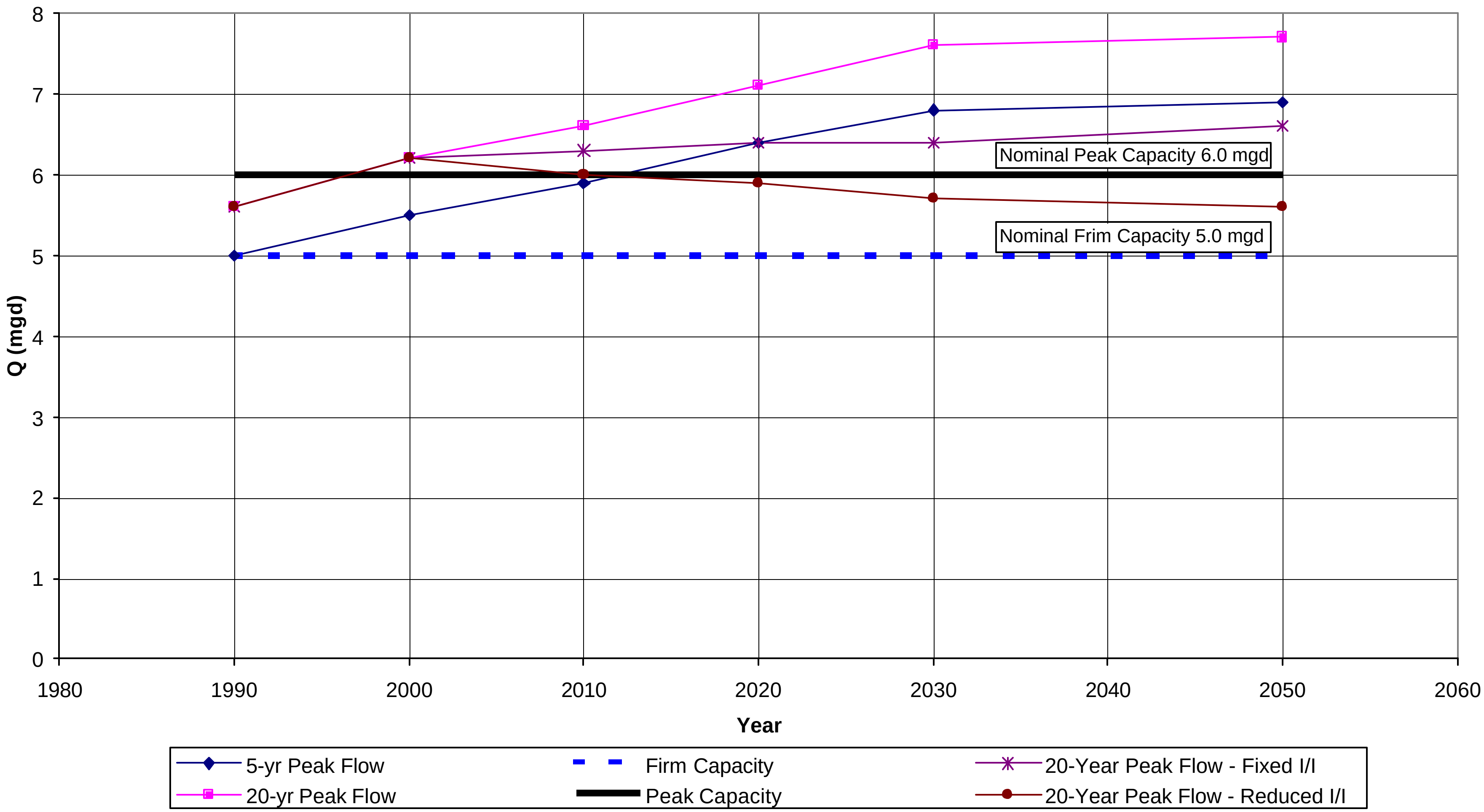
Given this high level of I/I for the Kirkland Pump Station Basin, it may prove to be more cost effective to reduce I/I rather than increase the capacity of the pump station. If the I/I program can offset the effect of the projected deterioration of the collection system (7 percent non-compounded increase in I/I per decade), the peak flow projections could be revised downward. For example, if the I/I program can offset the effects of system deterioration to year 2000 levels, the peak 20-year storm flow in 2050 would be 6.6 mgd (Table 2-2). This peak flow rate is 1.1 mgd less than the projected 20-year peak flow rate without any I/I control. If a more aggressive I/I program is implemented and a five percent reduction in I/I per decade can be achieved, the peak 20-year flow would be only 5.6 mgd. This reduction in I/I may alleviate or allow for the delay of capital improvement projects such as upgrading the pump station. Where applicable, potential capital cost savings associated with I/I reduction in the Kirkland Pump Station Basin will be discussed in association with the analysis of the alternatives to convey the projected flows.

Table 2-2. Flow Projections with I/I Reduction

Year	Base Flow (mgd)	Fixed[1]		Reduced[2]	
		20-yr I/I (gpad)	20-yr Peak (mgd)	20-yr I/I (gpad)	20-yr Peak (mgd)
1990	0.52	5,200	5.6	5,200	5.6
2000	0.72	5,580	6.2	5,580	6.2
2010	0.80	5,580	6.3	5,314	6.0
2020	0.89	5,580	6.4	5,061	5.9
2030	0.96	5,580	6.4	4,820	5.7
2050	1.09	5,580	6.6	4,591	5.6

Notes:
1. I/I rate fixed at year 2000 levels.
2. I/I rate reduced by five percent per decade starting in 2000 up to a total of 16 percent over the year 2000 I/I rates.

FIGURE 2-1
KIRKLAND PROJECTED FLOWS VS
EXISTING PUMP STATION CAPACITY



CHAPTER 3 – EXISTING KIRKLAND PUMP STATION

The Kirkland Pump Station is a two level structure. The wetwell and drywell with raw sewage pumps are on the lower level and electrical and other mechanical equipment is on the upper level. In general, the pump station is reliable and the structure is sound.

INFLUENT SEWER

The influent sewer is aligned at a fairly shallow slope of 0.3 percent for most of its length, and enters the wetwell at an invert elevation 120.40 feet (Metro Datum), 1.2 feet above the lead pump off elevation of 119.20 feet. As a result of this shallow slope, the capacity of one section of the influent sewer is limited to 5.3 mgd, which is approximately 0.7 mgd less than the reported peak capacity of the pump station (Table 3-1). In addition, the shallow slope results in lower wastewater velocities and a tendency for sediment to accumulate in the bottom of the pipe[1]. The velocity and hence the capacity of the pipe could be increased by lowering the invert of the pipe at the wetwell.

Table 3-1: Influent Sewer Hydraulics

Upstream STA	Downstream STA	Diameter (in)	Slope (ft/ft)	Q_{full} (mgd)
0+00	0+25	24	0.00344	8.60
0+25	3+06	24	0.00323	8.34
3+06	End of Pipe [1]	21	0.00270	5.33

Notes:
(1) Inside wall of pump station wetwell.

Lowering the invert of the pipe should also improve the hydraulics of the wetwell. Under existing conditions, wastewater cascades into the wetwell because the invert of the pipe is typically above the water surface. This cascading flow entrains air leading to reduced pump efficiency. Entrainment of one percent air in the sewage can decrease pump efficiency by 15 percent[2]. Entrained air can also cause air binding of the pumps, as has been reported for the pump closest to the influent sewer. To reduce the entrainment of air, the invert of the influent sewer should be lowered to the minimum water surface elevation in the wetwell. Bypass pumping and rerouting of the flow to the wetwell must be evaluated during predesign.

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[1] During a field visit on 2/3/99, six to eight inches of sediment were observed in the bottom of the first manhole upstream of the pump station.

[2] Reference: Sanks, et al, 1989. Pumping Station Design, pg. 308.

In the event of a mechanical or power failure to the pump station, wastewater can be stored in the wetwell and influent sewer for less than 20 minutes before overflowing at the Overflow Structure. The storage period ranges from approximately 17 minutes at the 1996 average dry weather flow (0.67 mgd) to 13 minutes at the 1996 average wet weather flow (0.85 mgd). Alternatives to increase the capacity of the influent sewer and providing storage are evaluated in Chapter 4.

KIRKLAND PUMP STATION

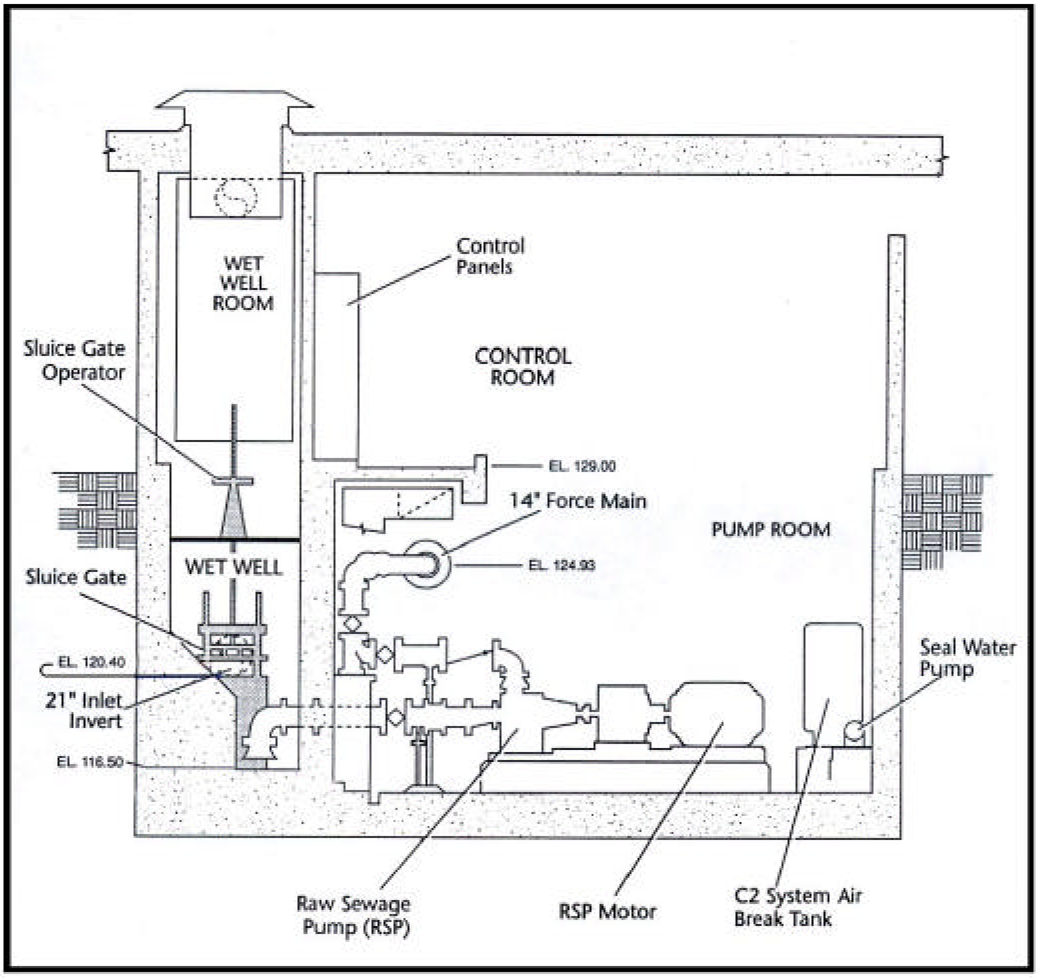
The pump station is a two level structure with a self-cleaning wetwell and drywell with raw sewage pumps on the lower level and electrical equipment on the upper level (Figure 3-1). The wetwell has a separate exterior entrance from the rest of the pump station and contains an influent sluice gate and exhaust fan. The lower level of the drywell includes the majority of the mechanical equipment, such as the compressed air system, sump pumps, and non-potable water system, as well as three raw sewage pumps. The area above the raw sewage pumps is open with a bridge crane and hoist to remove the pumps and other mechanical equipment. The HVAC equipment, motor control centers (MCCs), and main control panel (MCP) are located on the upper level of the drywell side of the pump station.

Raw Sewage Pumping System

The raw sewage pumping system includes a trench-type wetwell and three variable speed pumps that discharge into a common header connected to the 14-inch force main. Each component of the raw sewage pumping system was evaluated to determine what, if any, improvements are required.

Wetwell Hydraulics

Horizontal velocities in the wetwell are currently less than 1.0 fps, a standard hydraulic design parameter (Table 3-2). The wetwell should be able to convey the current 20-year peak flow without experiencing vortexing or similar hydraulic problems. However, if flows increase as projected and I/I control is not implemented, the horizontal velocities will increase to slightly more than 1.0 fps by 2010. Therefore, a more detailed analysis of the wetwell should be performed during predesign. Such an analysis would include an identification of potential performance problems and recommendations for wetwell modifications to improve approach flows to the pumps.



KING COUNTY
Conveyance System Improvements
Kirkland Pump Station

Figure 3-1
Pump Station Section

Table 3-2. Horizontal Velocities in the Wetwell

Q (mgd)	V_{horiz} [1] (fps)	Notes
0.9	0.19	AWWF – 1996 (0.87 mgd)
3.3	0.63	Flow with lead pump on.
4.7	0.72	Estimated pump station firm capacity.
5.6	0.86	Estimated pump station peak capacity.
6.5	1.00	*Maximum recommended horizontal velocity* [2]
6.6	**1.01**	Peak 20-year flow (2010). No I/I control.
6.6	**1.01**	Peak 20-year flow (2050). I/I control to 2000 rate.
7.7	**1.19**	Peak 20-year flow (2050). No I/I control.

Notes:
1. Horizontal velocity calculated in channel just upstream of the inlet to the first pump.
2. Reference: Pump Station Design, Sanks et al, 1st Ed. (1989). Pg. 312.
3. Velocities greater than the recommended value are **highlighted**.

Pump Suction

Velocities in the 10-inch pump suction lines were evaluated for a range of flows and compared to two standard design velocity criteria of 5 and 8 fps (Table 3-3). Based on this comparison, it appears that the velocity in the suction lines will be high for the projected 20-year peak flows, but will not necessarily require replacement of the suction lines.

Table 3-3. Pump Suction Velocities

$Q_{pump\ station}$ (mgd)	Q_{pump} [1] (mgd)	$V_{suction}$ (fps)	Notes
0.87	0.87	2.5	AWWF – 1996 (0.87 mgd)
5.3	1.8	5.0	Maximum recommended pump suction velocity[2].
6.2	**2.1**	**5.9**	Peak 20-year flow (2000).
6.6	**2.2**	**6.2**	Peak 20-year flow (2050). I/I control to 2000 rate.
7.7	**2.6**	**7.3**	Peak 20-year flow (2050). No I/I control.
8.5	**2.8**	**8.0**	Maximum recommended pump suction velocity[3].

Notes:
1. Based on three equally sized pumps.
2. Reference: Pump Station Design, Sanks et al, 1st Ed. (1989). Pg. 312.
3. Reference: Pump Station Design, Sanks et al, 2nd Ed. (1998). Pg. 361.
4. Velocities greater than the lowest recommended parameter are **highlighted**.

Raw Sewage Pumps

The raw sewage pumping system includes three variable speed pumps (Table 3-4). The speed of the pumps varies to match the raw sewage flow. Normally, the pumps operate with wastewater elevations in the wetwell between 2.7 and 3.8 feet above the bottom of the wetwell elevations (119.2 to 120.3 feet Metro Datum).

Table 3-4. Pump Parameters

Pumps	No. 1 and No. 2	No. 3
Model	Worthington 6 MF-15	Worthington 6 FS-2
Type	Non-clog centrifugal	Non-clog centrifugal
Design Flow	1,750 gpm	2,100 gpm
Design Discharge Head	189 feet	189 feet
Speed	1735 RPM	1750 RPM
Variable Speed Control	Electric Clutch	Electric Clutch
Motor Horsepower	150 HP	150 HP

Manufacturer pump curves were used to calculate system head curves for various operational conditions (Figure 3-2). Firm and peak pumping capacities were determined from these system-head curves based on Hazen-Williams Coefficients of 100, 110, and 120 and compared to measured values (Table 3-5). The calculated headloss at a Hazen-Williams Coefficient of 120 compare well with the firm (5.0 mgd) and peak (6.0 mgd) pump station capacities stated in the *Kirkland Pump Station Operation and Maintenance Manual*. However, based on available flow data, a Hazen-Williams Coefficient of 110 more accurately represents the condition of the Kirkland Pump Station force main. Therefore, it appears that the actual firm and peak capacities of the Kirkland Pump Station are approximately 4.7 mgd and 5.6 mgd respectively.

Table 3-5. Pump Station Capacities

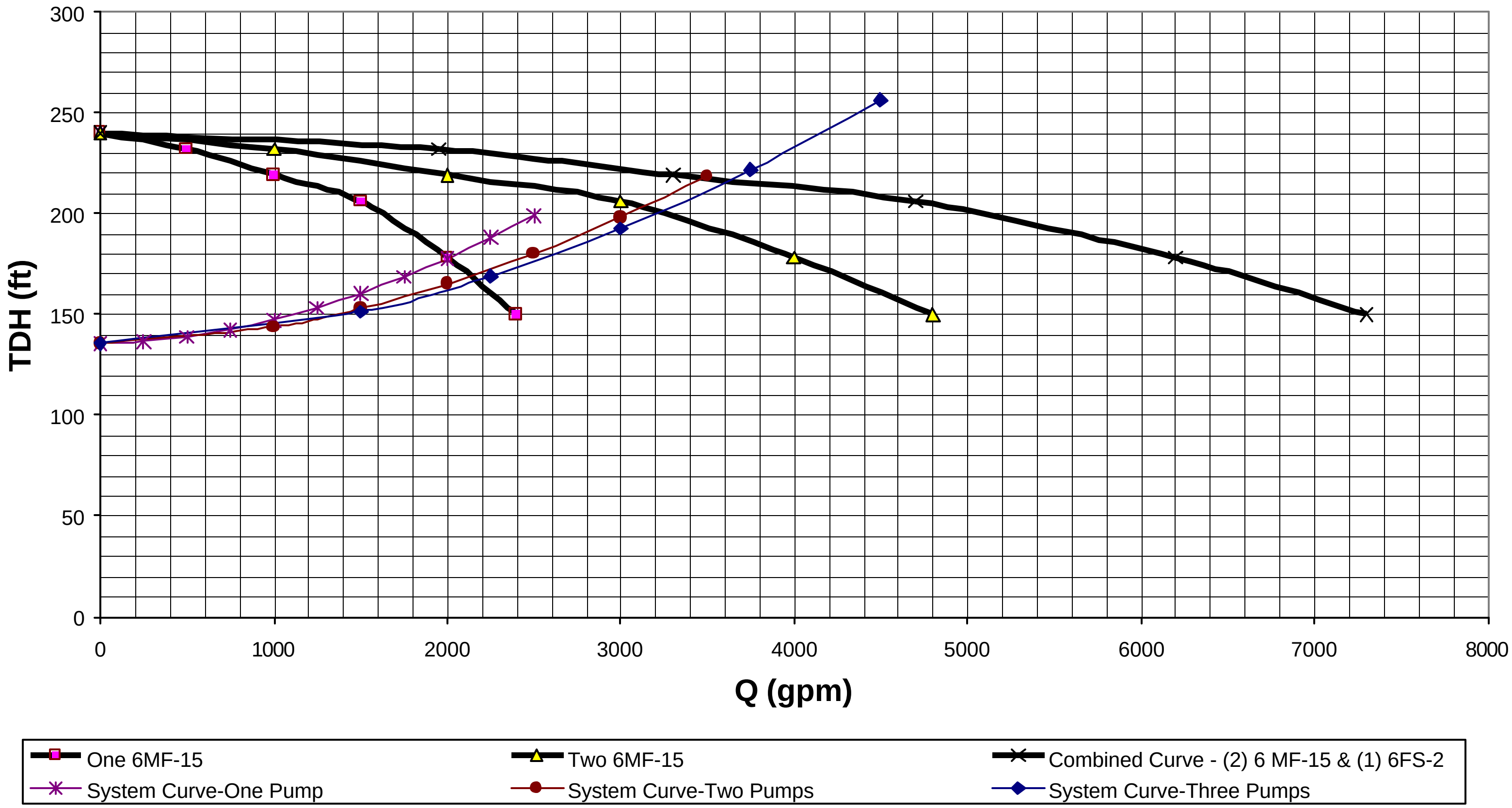
Pumps	Measured [1]	C_{HW}=100	C_{HW}=110	C_{HW}=120
	Flow (mgd)			
1	2.3	2.9	3.0	3.2
2 (Firm)	4.7	4.4	4.7	5.0
3 (Peak)	NA[2]	5.2	5.6	6.0

Notes:
1. Measured flows based on average of 10 measured values when the pumps were operating at full speed on February 8, 1996.
2. Flows greater than 5 mgd, the upper limit of the flowmeter span.

Pump Discharge Piping

Velocities in the 8-inch pump discharge piping were evaluated for a range of flows and compared to two standard design velocity criteria of 8 and 12 feet-per-second (fps) (Table 3-6). Based on this comparison, it appears that the velocity in the discharge lines will be high for the projected 20-year peak flows, but will not necessarily require replacement of the discharge lines.

FIGURE 3-2
KIRKLAND PUMP STATION
EXISTING RAW SEWAGE PUMP CURVES



Note: Pumps at full speed.

Table 3-6. Pump Discharge Velocities

$Q_{pump\ station}$ (mgd)	Q_{pump}[1] (mgd)	$V_{discharge}$ (fps)	Notes
0.87	0.87	3.9	AWWF – 1996 (0.87 mgd)
5.4	1.8	8.0	Maximum recommended pump discharge velocity[2].
6.2	**2.1**	**9.2**	Peak 20-year flow (2000).
6.6	**2.2**	**9.8**	Peak 20-year flow (2050). I/I control to 2000 rate.
7.7	**2.6**	**11.5**	Peak 20-year flow (2050). No I/I control.
8.1	**2.7**	**12.0**	Maximum recommended pump discharge velocity[3].

Notes:
1. Based on three equally sized pumps.
2. Reference: Pump Station Design, Sanks et al, 1st Ed. (1989). Pg. 312.
3. Reference: Pump Station Design, Sanks et al, 2nd Ed. (1998). Pg. 361.
4. Velocities greater than the lowest recommended parameter are **highlighted.**

Pump Speed Control

Eddy-current couplings (ECCs) control the pump speed and discharge for each raw sewage pump. ECCs, also commonly referred to as electric clutches, are not as energy efficient as VFDs. Since the pumps need to be replaced to convey higher flows, the ECCs will be undersized and should be replaced with VFDs.

Flow Isolation and Bypassing Capabilities

In case of an extreme emergency, flow can be diverted from the pump station by closing the manually operated influent sluice gate. This closure would cause an overflow at the existing overflow structure. Pumps can be individually isolated by closing the manually operated suction and discharge isolation valves.

Control System

The pump station is fully automatic, normally unattended, and controlled from panels in the control room. Staff at the South Treatment Plant in Renton monitor the operations of the pump station through the Forney and Metrotel SCADA systems. These systems allow King County staff to monitor wetwell elevations, pump speed, and pump station flow, as well as be alerted to the failure of critical process components. The existing SCADA system functions well. The County is currently undertaking a program to replace existing Texas Instruments (TI) PM550 PLCs with Modicon units at offsite facilities.

The pumps are controlled by the wastewater level in the wetwell, which is measured by a bubbler in the wetwell. The wetwell lacks a redundant system of float switches to turn on the pumps should the bubbler system fail. Float switches should be installed to provide a redundant means for controlling the pumps. The installation of a redundant raw sewage pump control system is King County standard practice for offsite facilities.

The existing wastewater flowmeter is located in the drywell on the force main adjacent to the exterior wall on the lower level. This strap on ultrasonic flowmeter is located less than 3 feet downstream from the nearest fitting. Strap on ultrasonic flowmeters are typically not as accurate as newer magnetic flowmeters. In addition, manufacturers recommend that these flowmeters be installed with at least five straight pipe diameters downstream and two straight pipe diameters upstream of the unit. Therefore, the existing flowmeter should be replaced as a part of the next pump station upgrade with one installed in accordance with the manufacturer recommendations. This installation will probably require that the flowmeter be placed outside in a vault.

Air System

The air system provides instrument air for the wetwell bubblers and control panel. The system consists of duplex air compressors, receiver, and ancillary equipment. An air cylinder on the upper level provides air if the compressor fails. This system has worked reliably and the equipment was recently replaced. The instrument air supply system functions well. Regardless, float switches should be provided as a redundant pump control system in the event that the air system fails. County standards require duplex compressors, a standby air cylinder, and multiple float switches for pump control and alarm.

Standby Power and Electrical System

Power is supplied to the pump station by Puget Sound Energy (PSE) from two separate substations. In the event power is lost from the primary substation, there is an automatic transfer switch (ATS) on the northside of the pump station to switch to an alternate power supply source from PSE. From this ATS, the power supply goes to a pad mounted 300 kVA transformer located near the northwest corner of the facility.

In the event power is lost from both the primary and secondary external supplies, power is supplied to the station by a 562 kVA/450 kW pad mounted generator located outside on the west side of the facility. This generator has the capacity to operate all three existing pumps. The generator enclosure includes a 275 gallon diesel fuel storage tank mounted beneath the generator. Based on a full-load fuel consumption rate of 35 gallons-per-hour, the fuel tank has sufficient storage capacity to run the generator for slightly less than 8 hours. A minimum of 24 hours of storage is typically provided for County offsite facilities. However, such a large above ground storage tank was not permitted since a 10-foot setback from the property line is required by the Uniform Fire Code for tanks with a capacities of greater than 275 gallons and such a setback is not feasible given the small lot size. Locating an underground storage tank just south of the generator could provide this storage with the existing pad mounted storage tank serving as a day tank.

The existing switchgear and motor control centers (MCCs) were installed in 1966. This equipment is old and reportedly in need of replacement. This equipment replacement may be required before the next pump station upgrade. The timing of this equipment replacement is dependent, in part, on the timing of the next pump station upgrade.

Water System

The existing water system includes both potable (C1) and non-potable (C2) water systems. The potable water service water enters the station through a 2-inch diameter line that connects to the reduced-pressure backflow preventer on the south wall of the pump station. The C1 water system provides water for drinking, the restroom, and landscape irrigation. The C2 water system is separated from the C1 water system by an air break tank and subsequently is divided into two subsystems, one for flushing water and the other primarily for seal water for the raw sewage pumps. The C2 low pressure water system provides water for station washdown, pipe and pump flushing, and general maintenance. The C2 high pressure (C2HP) water system includes two high head (125 feet TDH) pumps to serve the pump seals.

The existing backflow preventer is located below ground level. As such, it does not meet code[3]. In addition, the irrigation line does not have a backflow preventer to separate it from the C1 water system in the pump station. The water system must be modified to meet code as part of the next pump station upgrade.

Each of the two 1.5 horsepower C2HP pumps is rated for 10.4 gallons per minute (gpm) at 125 feet connected to a hydropneumatic tank that operates at 50-75 psi. Two pumps are necessary to ensure seal water is provided in case one pump fails. Good design practice includes providing 2 gpm of seal water for each pump at 5 psi above the pump discharge pressure. Since the maximum pressure provided by the hydropneumatic tank is 75 psi (173 feet), the existing seal water system appears to be slightly undersized. The hydropneumatic tank must be adjusted or replaced and the seal water pumps replaced to prevent contaminants and abrasive material from entering the packing and causing excessive shaft wear.

The County primarily uses stuffing boxes with packing to seal against raw sewage leakage around the pump shaft. Historically, the County has not had good success with mechanical seal systems once the seals were replaced or rebuilt. For these reasons, the County has used mechanical seals, including flushless mechanical seals that do not require seal water, in only a very limited number of applications. A reliable seal water system is essential for continued successful operation of the main sewage pumps.

Drainage System

The drainage system consists of sump and sump pumps located in the northeast corner of the pump room. The drainage system collects wastewater from various equipment and pump room drains. From the sump, wastewater is discharged through a 3-inch diameter line to the influent manhole. The drainage system includes one float-controlled pump located in the sump and another float-controlled pump on the floor of the pump room adjacent to the

[3] E-mail from Severne Johnson to Chris Okuda, Sarah Draper, and Mann Ling Thibert, 2/3/98.

sump. The floor-mounted pump only operates if the sump overflows onto the floor of the pump room. Although the additional sump pump was retrofit to the existing system, the drainage system is adequate and no modifications are required.

HVAC System

The existing heating and ventilation system operates continuously to supply fresh air throughout the pump station. In addition, the system maintains a nearly constant temperature within the facility and removes noxious, odor producing gases from the wetwell. Air is supplied to the facility from one supply fan with a rated capacity of 5,000 cubic-feet-per-minute (cfm).

NFPA 820 requires that the drywell and other parts of the pump station not exposed to sewer gases be ventilated continuously at six air-changes-per-hour (ACH). In addition, the system should be designed to maintain a net positive pressure in the drywell and connected areas. The HVAC system provides more than enough air to meet the six ACH requirement. However, the supply rate and exhaust rates are shown to be equal on the drawings. Based on this information, the drywell is probably not maintained under a positive pressure of 0.1 inch water column in accordance with NFPA 820 requirements.

NFPA 820 stipulates that the wetwell and wetwell access be ventilated continuously at 12 ACH. Based on this air change rate, the calculated airflow requirement is 500 cfm. According to the design documents, 5,000 cfm of air is provided to the wetwell, significantly more than required. In addition, the wetwell area must be maintained under a negative pressure of 0.1 inch water column. With equal supply and exhaust air rates, this requirement does not appear to be met.

Air is supplied to the wetwell from the drywell. This approach for providing air to the wetwell was common when the pump station was built. However, cross connection of air between the wetwell area and the pump/control rooms are prohibited by current codes unless all areas are classified as Class I, Division 2, Group C & D. This classification requires that all equipment be explosion proof, which it currently is not. Complete separation of wetwell and drywell air must be provided as a part of any pump station improvements.

Odor control is currently not provided for the pump station and reportedly there have been no odor complaints. As a result, there are no plans to provide odor control for the pump station.

Equipment Accessibility and Maintenance Considerations

The open bay design allows for relatively easy equipment access. There is a two-ton monorail and electric hoist above the raw sewage pumps to facilitate removal and installation of large pieces of equipment such as pumps and motors. This hoist is the only one in the pump station.

Personnel Egress, Safety, and Code Issues

The Uniform Building Code (UBC) defines means of egress and fire protection requirements for structures. In the Kirkland Pump Station, there are separate external entrances for the drywell and wetwell. Under current code, a single means of egress is sufficient as long as the occupant load is 10 or less. In addition, the maximum travel distance is 200 feet for nonsprinklered buildings such as the pump station. Therefore, the pump station with a single means of egress from the drywell and another means of egress from the wetwell meets the requirements of the UBC.

The grating in the wetwell extends the width of the wetwell. To properly washdown the wetwell, maintenance personnel must remove sections of grating. When the grating is removed, the potential existing for maintenance personnel, equipment, and grating to fall into the wetwell. The existing grating should be replaced to allow at least one foot clear between each side of the grating and side of the wetwell. Such clearance would still allow for a 3-foot wide walkway down the middle of the wetwell. The replacement of grating will facilitate wetwell washdown and eliminate the potentially unsafe condition that exists when grating sections are removed.

Spiral stairs provide access to the lower level of the pump station drywell. Although spiral stairs are acceptable for certain limited situations described in the UBC and OSHA regulations, they are not recommend for new facilities when other means of egress can be provided[4,5]. However, the spiral stairs are already part of the pump station and replacement of the spiral stairs in the existing pump station with another means of egress is not practical given the space constraints of the existing facility.

Automatic sprinklers systems are required in certain situations. The two situations that were evaluated for the existing pump station include:

- For basements and stories exceeding 1,500 square feet without requisite exit openings; and
- For Group H occupancies.

Hazardous chemicals currently are not stored in the pump station and the floors of the pump station are all less than 1,500 square feet so automatic sprinklers are not required.

The sound level in the pump station is reportedly 92-97 dBA. An effective hearing protection program must be made available whenever employee exposures equal or exceed

[4] Uniform Building Code (1997 – Latest Edition)- Section 1003.3.3 –"Stairs or ladders used only to attend equipment or window wells are exempt from the requirements of this section."

[5] OSHA 1910.24 (b) – " . . .Spiral stairs shall not be permitted except for special limited usage and secondary access situations where it is not practical to provide a conventional stairway."

an 8-hour time weighted average (TWA) sound level of 85 dBA[6]. In addition, feasible administrative and engineering controls must be implemented whenever employee exposures equal or exceed an 8-hour TWA sound level of 90 dBA. Although operation and maintenance personnel are not normally in the pump station for 8-hour periods, some maintenance tasks may require personnel to be in the station for up to 8 hours. Measures to reduce the sound level in the pump station should be included in the next pump station upgrade. Noise reduction measures include the replacement of noise equipment such as the ECCs, and noise attenuation measures such as acoustical panels on the walls and ceiling.

KIRKLAND FORCE MAIN

Wastewater is discharged from the Kirkland Pump Station into a single 14-inch diameter force main, which extends approximately 3,210 feet from the pump station to the discharge point in the ESI. The force main profile is included as Figure 3-3. The wastewater velocity is less than 1.0 foot per second at the ADWF and greater than 8.0 feet per second at peak flows of 6.0 mgd (Table 3-7). Velocities greater than 8.0 feet per second result in excessive pipe frictional losses, larger horsepower requirements, and the potential for more severe hydraulic transients. Even with I/I control, peak flows are projected to increase well above 5.5 mgd. Therefore, a larger or parallel force main appears to be warranted for hydraulic reasons. Force main replacement alternatives are discussed in Chapter 4.

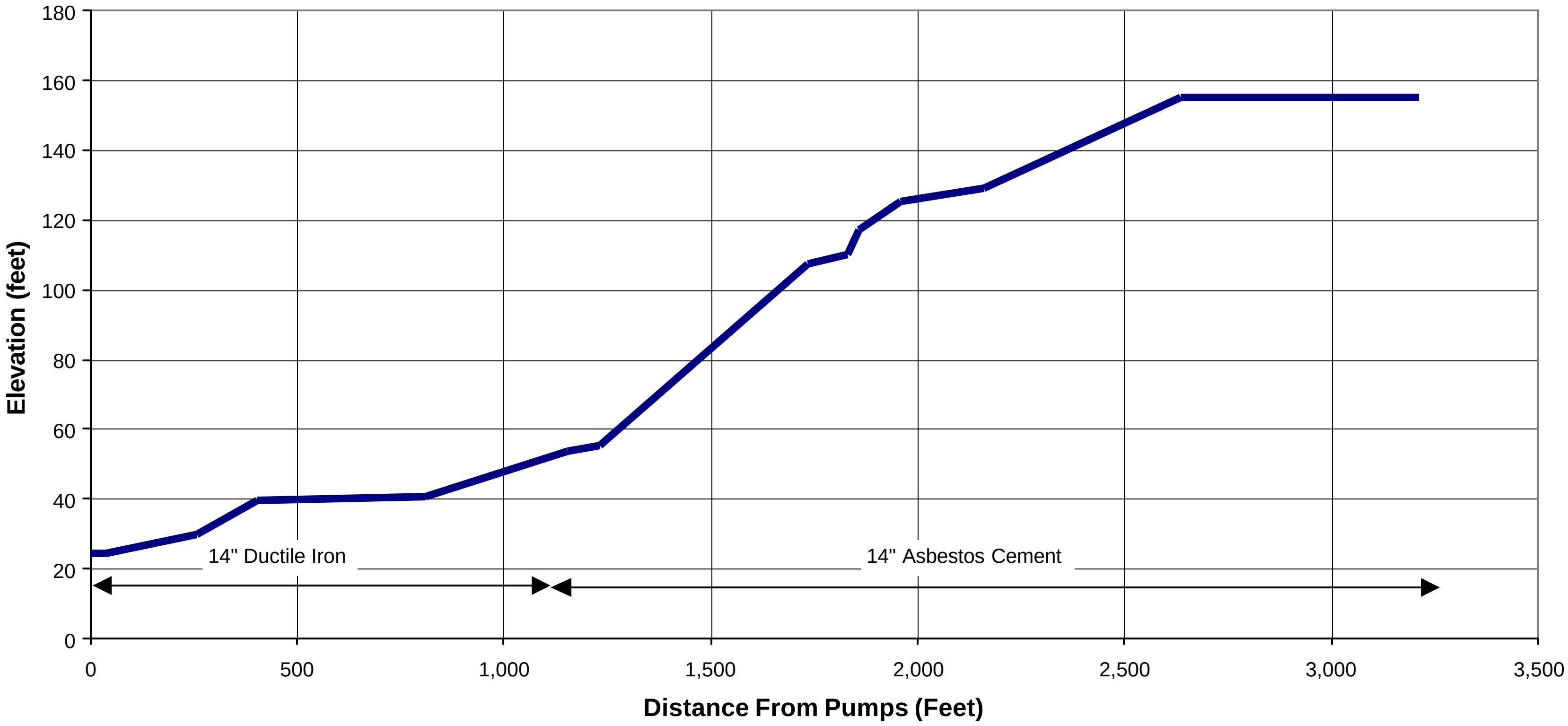
Table 3-7. Force Main Wastewater Velocities

Q (mgd)	V (fps)	NOTES
0.9	1.26	AWWF (1997)
4.7	6.80	Estimated Firm Pump Station Capacity
5.5	8.00	Maximum Design Velocity
5.6	**8.10**	Estimated Peak Pump Station Capacity
6.6	**9.55**	Peak 20-year flow (2050). I/I control to 2000 rate.
7.7	**11.14**	Peak 20-year flow (2050). No I/I control.

Notes:
1. Velocities greater than the recommended value are **highlighted.**

[6] OSHA Regulations: 29 CFR 1910.95. Subpart G(b).

FIGURE 3-3
KIRKLAND FORCE MAIN PROFILE



Hydraulic Transients

The Kirkland Pump Station has not reportedly experienced severe hydraulic transients. In March 1999, Golden Anderson Industries, a supplier of air release, air vacuum, and surge relief valves, conducted preliminary surge analyses for the force main to estimate the potential severity of the hydraulic transients. These surge analyses were performed for the 14-inch force main for flows slightly greater than the existing firm and peak capacities of the pump station. These surge analysis parameters included:

- Initial Conditions: 3,800 gpm (5.5 mgd) and 4,700 gpm (6.8 mgd).
- Estimated Total Combined Pump and Motor WR^2: 200 ft-lbs.
- Pump Check Valves: Air-dampened slow closing check valves.

The maximum upsurge values predicted by the model were compared to the following pressure threshold values of the existing force mains:

- Pump discharge piping and force mains: The first 1,100 feet of force main from the pump station are Class 52 ductile iron pipe, which has a rated working pressure of 350 psi plus a 100 psi surge allowance. Based on these assumptions, the maximum allowable upsurge is 450 psi (1,040 feet)[7]. The upper 2,100 feet of the force main are asbestos-cement pipe (ACP). ACP is available with working pressures of 100, 150, and 200 psi. Each length of Class 100 ACP is tested at 350 psi (807 feet), which was assumed to be the minimum surge rating of the force main pipe.
- Pump discharge and valve flanges: Valve and pump discharge flanges were assumed to be Class 125 which have a rated working pressure of 250 psi (577 feet).
- Thrust restraint: Thrust restraint blocks designed for a test pressure of 150 psi (350 feet) were provided at bends in the force main.

The surge analyses indicated that some severe hydraulic transients can occur approximately 15 seconds after a power failure. The maximum upsurge pressure was approximately 150 psi (350 feet) at the pump station. This surge pressure is approximately equal to the rated test pressure of the force main thrust restraint, and significantly less than the surge rating for the force main and flange fittings. However, the ACP was installed in 1966 and may have deteriorated over the years to a point where it can no longer withstand peak surge pressures. As evidence of this deteriorated pipe condition, some leaks have been reported in the Kirkland Pump Station force main. This preliminary hydraulic transient analysis should be confirmed with a more detailed, independent analysis during predesign, especially since the projected peak flows are slightly greater than the flows used these analyses.

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[7] All ductile iron and steel pipe is designed with a factor of safety of 2.

PUMP STATION PROBLEMS SUMMARY

The Kirkland Pump Station has a number of operational problems under existing flow conditions that will be exacerbated as flows to the pump station increase. These problems are summarized in Table 3-8. These problems are classified as either of higher or lower significance based on the potential for the problem to disrupt pump station operations or otherwise compromise the ability of the pump station to convey wastewater. In addition, there are several relatively minor problems with the ancillary systems for the pump station that are also summarized in Table 3-8. The potential solutions and costs to fix these problems are described in the Chapter 4.

Based on the severity of the potential problem, the higher priority items are:

- The influent sewer enters the wetwell above the normally operating water surface and is limited to 5.3 mgd without surcharging the line. The influent sewer should be aligned at a steeper slope from the overflow structure to the wetwell to increase the sewer capacity, wastewater velocities, and minimize air entrainment of wastewater in the wetwell.
- The switchgear, MCCs, and associated electrical equipment should be evaluated and replacement scheduled.
- The ACP section of the existing force main should be replaced.

The hydraulic transients of the Kirkland Pump Station force main under the existing firm and peak capacities of the pump station were evaluated. Based on this evaluation, additional surge protection for the force main is not required. This preliminary hydraulic transient analysis should be confirmed with a more detailed, independent analysis during predesign.

Table 3-8. Summary of System Problems

System	Significance		Notes
	Lower	Higher	
Kirkland Pump Station			
Influent Sewer		X	The invert of the influent sewer entering the wetwell should be lowered to increase the capacity of the sewer, increase the wastewater velocity, and minimize air entrained in the sewage in the wetwell.
Raw Sewage Pumps	X		Suction and discharge velocities are projected to be slightly higher than the lower end of standard design parameters at projected 20-year peak flows.
Control System		X	Some equipment is old and needs to be replaced. VFDs should be installed when pumps are replaced. Redundant raw sewage pump controls should be provided in the wetwell. A new flowmeter should be installed.
Standby Power	X		The generator fuel tank provides less than 8 hours capacity at full load.
Electrical Equipment		X	The switchgear and MCCs should be evaluated and replacement scheduled.
Water	X		Backflow preventer is located below ground level. A backflow preventer must be provided on the irrigation water.
HVAC	X		Cross connection between the wetwell and drywell
Personnel Egress and Safety	X		Grating in the wetwell should be replaced to facilitate washdown of the wetwell and improve worker safety. Sound level excessive.
Kirkland Force Main			
Capacity		X	At 5.5 mgd, the forcemain velocity is approximately 8.0 fps. Since peak flows are projected to increase above 5.5 mgd, increasing the force main capacity should be evaluated. The asbestos cement section of the existing force main should be replaced.
Hydraulic Transients	X		Surges significantly less than surge rating of the pipe and flanges. Preliminary surge analysis should be confirmed during predesign.

CHAPTER 4 – ALTERNATIVE EVALUATION

Based on the projected increased flow to the pump station in Chapter 2, improvements were identified to convey the projected peak 5-year and 20-year flows to the ESI. County design requirements stipulate that the firm pumping capacity of the station is sufficient to convey the 5-year storm flow and the peak pumping capacity is sufficient to convey the 20-year storm flow. Some improvements to the pump station are independent of flow, while others are dependent upon certain hydraulic criteria being exceeded. Examples of these hydraulic criteria are flows greater than the peak pump station capacity, and velocities in the force main greater than 8 feet-per-second (fps). For discussion purposes, these improvements are divided into those that are independent of flow and could be performed as part of an initial upgrade, and those that are dependent upon projected flow increases.

The Kirkland Pump Station has not reportedly had any odor problems. A previous study did not recommend odor scrubbing of the air exhausted from the wetwell or chemical addition to control sulfide production in the force main[8]. The only recommendation was modification of the discharge structure into the force main to minimize the release of hydrogen sulfide at this location. Modifications to the discharge structure were not included as part of the analysis of the pump station since these modifications will most likely be addressed separately as part of the collection system odor control improvements.

INITIAL UPGRADE

The initial upgrade includes those items required to correct problems with the existing pump station that are independent of flow projections. These improvements could be implemented prior to or included with an upgrade of the pump station to meet higher projected flows. Recommended improvements include:

- Realign and upsize the influent sewer;
- Replace grating in the wetwell;
- Provide float switches in the wetwell;
- Install a new flowmeter;
- Replace electrical equipment;
- Modify the HVAC system;

[8] East Side Interceptor Chemical Injection Facility Feasibility Study. Final Draft. Prepared by Black and Veatch. December, 1998.

- Replace the backflow preventer;
- Upgrade the seal water system;
- Install a larger capacity diesel fuel storage tank;
- Provide improved noise attenuation; and
- Make aesthetic improvements to the pump station exterior.

Influent Sewer

The section of influent sewer from the first upstream manhole to the wetwell has a limited capacity of 5.3 million gallons per day (mgd). This influent sewer capacity is approximately 0.3 mgd less than the estimated firm capacity of the pump station. In addition, the influent sewer from the overflow structure to the wetwell is aligned at a fairly shallow slope of 0.3 percent. The velocity and hence the capacity of the pipe could be increased by lowering the invert of the pipe at the wetwell. Lowering the invert of the pipe should also improve the hydraulics of the wetwell. Under existing conditions, wastewater cascades into the wetwell because the invert of the pipe is typically above the water surface in the wetwell. This cascade entrains air in the wastewater and releases malodorous gases.

Replacing the existing influent sewer is recommended for the following reasons:

- To increase the capacity of the influent sewer from the overflow structure to the wetwell;
- To increase the upstream storage volume; and
- To minimize the release of malodorous gases and the entrainment of air in wastewater entering the wetwell.

Replacement of the pipe from the overflow structure to the wetwell with a pipe at a steeper slope will increase the capacity of the influent sewer and reduce the entrainment of air in the wetwell. If the influent pipe were replaced with a 24-inch pipe from the overflow structure to the wetwell and the invert elevation of the wetwell lowered to 120.0 feet (King County/Metro Datum), the full pipe capacity of the most hydraulically limited section of the influent sewer would increase significantly from 5.3 mgd to 8.6 mgd (Table 4-1). This increased sewer capacity of 8.6 mgd is significantly greater than the 5.6 mgd estimated peak capacity of the existing pump station and 7.7 mgd projected peak 20-year flow in 2050 without I/I reduction.

Table 4-1. Influent Sewer Replacement

Upstream STA	Downstream STA	Diameter (in)	Slope (ft/ft)	Q_{full} (mgd)
0+00	0+25	24	0.00344	8.60
0+25	3+06	24	0.00430	9.61
3+06	End of Pipe [1]	24	0.00450	9.83

Notes:
(1) Inside wall of pump station wetwell.

To increase the storage capacity in the influent sewer, the feasibility of installing a larger diameter influent sewer was evaluated. The crown of the existing influent sewer is approximately 2.9 feet below the surface of the street at the overflow structure. Typically, a minimum of two feet of cover is provided, but this could be reduced to 1.5 feet with a concrete cap. Based on this minimum cover and 5-inch pipe wall thickness for reinforced concrete pipe, the influent sewer can be no larger than a 36-inch diameter pipe. The other restriction is that no wastewater can be stored in the influent sewer above 123.31 feet (KC Metro Datum), the elevation of the overflow weir. This overflow constraint is more restrictive than the minimum cover requirement. Based on installing a 36-inch diameter influent pipe from the pump station to downstream of the overflow weir, the increase in storage is limited to about seven additional minutes at an average dry weather flow of 0.67 mgd or about 24 minutes total (Table 4-2). Off-line storage can be evaluated during predesign if additional storage is required.

Table 4-2. Influent Sewer Detention Time

Alternative	Total Storage Volume [3] (gal)	Hydraulic Detention Time at ADWF [3] (minutes)	Minimum Q_{full} (mgd)
Existing Conditions	8,040	17	5.30
(1)	8,820	19	8.60
(2)	11,160	24	8.60

Notes:
(1) Upsize first upstream segment of influent sewer to a 36-inch diameter pipe and increase the slope on the influent sewer.
(2) Upsize first upstream segment of influent sewer to a 36-inch diameter pipe, increase the next upstream segment to a 30-inch diameter pipe and increase the slope on the influent sewer.
(3) Based on (total pipe volume) – (flow) + (available storage in the wetwell).

Wetwell Grating

The grating in the wetwell extends the full 5-foot width of the wetwell. To properly washdown the wetwell, maintenance personnel must remove sections of grating. When the grating is removed, the potential exists for maintenance personnel, equipment, and grating to fall into the wetwell. The existing grating should be replaced to allow one foot clear between each side of the grating and side of the wetwell. Such clearance would still allow for a 3-foot wide walkway down the middle of the wetwell complete with railings and toeplates. The replacement of grating will facilitate wetwell washdown and eliminate the potentially unsafe condition that exists when grating sections are removed.

Wetwell Float Switches

The pumps are controlled by a bubbler system that measures the wastewater level in the wetwell. The wetwell lacks a redundant system of float switches to control the pumps should the bubbler system fail. Float switches should be installed to provide a redundant means for controlling the pumps. The installation of a redundant raw sewage pump control system would put the station in compliance with King County standard practice for offsite facilities.

Flowmeter

The existing wastewater flowmeter is located in the drywell on the force main less than three feet downstream from the nearest fitting. Manufacturers recommend that these flowmeters be installed with at least five straight pipe diameters upstream and two straight pipe diameters downstream of the meter. One way to provide a flowmeter with the requisite length of straight pipe upstream and downstream is to install the flowmeter in a vault beneath the sidewalk just east of the pump station.

Electrical Equipment

The existing switchgear and motor control centers (MCCs) were installed in 1966. Based upon information provided by King County electrical and maintenance staff, they are in need of replacement. For budgetary planning purposes, it was assumed that the existing 15 kV automatic transfer switch and MCCs would be replaced.

HVAC System

Air is supplied to the wetwell from the drywell. This approach for providing air to the wetwell was common when the pump station was built. However, cross connection of air between the wetwell area and the pump/control rooms is prohibited by current codes unless all areas are classified as Class I, Division 2, Group C & D. This classification requires that all equipment be explosion proof, which it currently is not. A new air handling unit and exhaust fan for the drywell and new supply and exhaust fans for the wetwell would be required to provide complete separation of wetwell and drywell air.

Backflow Preventer Modifications

The existing backflow preventer is located below ground level. Therefore, it does not meet code or King County design standards[9]. In addition, the irrigation line does not have a backflow preventer to separate it from the C1 water system in the pump station. The water system should be modified to meet code as part of the next pump station upgrade. This upgrade would include relocating the backflow preventer to the upper level of the pump station adjacent to the rollup door on the south interior wall of the pump station and installation of anti-siphon valves or a similar approved backflow preventer on the irrigation line.

Seal Water System

Each of the two 1.5 horsepower C2HP pumps is rated for 10.4 gallons-per-minute (gpm) at 125 feet connected to a hydropneumatic tank that operates at 50-75 pounds per square inch (psi). Two pumps are necessary to ensure seal water is provided in case one pump fails. Good design practice includes providing two gpm of seal water for each pump at five psi above the pump discharge pressure. Since the raw sewage pump discharge pressure is approximately 214 feet when all three pumps are operating and the maximum pressure provided by the hydropneumatic tank is 75 psi (173 feet), the existing seal water system appears to be undersized. The hydropneumatic tank must be adjusted or replaced and the seal water pumps replaced to prevent contaminants and abrasive material from entering the packing and causing excessive shaft wear. This adequately pressurized seal water will become more critical if a decision is made to use mechanical seals on the raw sewage pumps.

Underground Diesel Storage Tank

In the event power is lost from both the primary and secondary external supplies, power is supplied to the station by a 450 kW pad mounted generator with a 275 gallon diesel fuel storage tank mounted beneath the generator. Based on a full-load fuel consumption rate of 35 gallons-per-hour, the fuel tank has sufficient storage capacity to run the generator for slightly less than eight hours. A minimum of 24 hours of storage is typically provided for County offsite facilities.

A 1000-gallon storage tank would be sufficient to provide this storage. Given the size of the site and uniform fire code (UFC) setback requirements, it is not feasible to locate a 1000-gallon above grade storage tank on the pump station site. These UFC restrictions do not apply to underground storage tanks. It is possible to locate an underground storage tank just south of the existing engine generator. The County should compare the liability and regulatory requirements associated with an underground storage tank versus the need to

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[9] E-mail from Severne Johnson to Chris Okuda, Sarah Draper, and Mann Ling Thibert, 2/3/98.

have more than eight hours of fuel storage. For example, it could be argued that additional fuel could be delivered within an eight hour period to extend emergency generator operation if need be.

Noise Attenuation

The sound level in the pump station is reportedly 92-97 dBA. An effective hearing protection program must be made available whenever employee exposures equal or exceed an eight-hour time weighted average (TWA) sound level of 85 dBA[10]. In addition, feasible administrative and engineering controls must be implemented whenever employee exposures equal or exceed an eight-hour TWA sound level of 90 dBA. Although operation and maintenance personnel are not normally in the pump station for eight-hour periods, some maintenance tasks may require personnel to be in the station for up to eight hours.

The walls of the pump station are concrete masonry units while the ceiling is concrete. These surfaces reflect approximately 95 percent of the incident sound from the pumps and other equipment back into the room. Aluminum encased fiberglass panels installed on the available ceiling and wall surfaces would reduce the reverberant sound levels by approximately 4-6 dBA, or to 86-93 dBA. Further noise reduction would require installation of sound enclosures around noisy equipment. Since enclosures would make access to the pumps difficult, noise attenuation at this planning level was limited to wall and ceiling mounted acoustical panels.

Aesthetic Improvements

Maintenance personnel have reported drainage problems and debris buildup in the planters on the building perimeter. Options to improve drainage and debris buildup include changes to the drainage piping and modifications to the landscaping. Incorporation of these improvements should also reduce maintenance costs.

UPGRADE FOR INCREASED FLOWS

Additional work will be required to convey the projected increased flows to the pump station. For planning purposes, these upgrades were developed with the goal of providing a peak pump station capacity of 7.7 mgd, the projected 20-year peak flow in 2050 without I/I control. Most of these improvements are related to replacement of the pumps and associated piping, and include the following:

- Replace pumps, discharge piping, and force main header;

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[10] OSHA Regulations: 29 CFR 1910.95. Subpart G(b).

- Replace the suction piping and modify the wetwell to accommodate the increased flows; and
- Replace the ACP section of the existing force main.

Parallel and Replacement Force Mains

Wastewater is currently discharged from the Kirkland Pump Station into a single 14-inch diameter force main, which extends approximately 3,210 feet from the pump station to the discharge point at the ESI. The majority of this force main is constructed of asbestos-cement pipe (ACP). In 1996, the first 1,113 feet of the force main was replaced with 14-inch Class 52 ductile iron pipe. Reportedly, some sections of the remaining 2,100 feet of ACP force main have leaked and been replaced. Based on these reported failures of the pipe and the fact that the force main is 34 years old, the ACP sections of the force main should be replaced.

Three forcemain replacement alternatives were evaluated:

- Replace the ACP with a 14-inch pipe;
- Replace the ACP with an 18-inch pipe; and
- Replace the ACP with a 14-inch pipe and construct a parallel force main.

These alternatives were evaluated to determine the effect of each on the pump station motor horsepower requirements. A Hazen-Williams Coefficient of 110, pump efficiency of 70 percent, and motor efficiency of 90 percent were used in this evaluation. Based on these parameters, the maximum flow that could be conveyed with three 150 horsepower (Hp) pumps and the existing forcemain and discharge piping is approximately 6.6 mgd (Table 4-3). If the existing ACP is replaced with an 18-inch diameter pipe, the maximum flow that could be conveyed wit the 150 Hp pumps would be approximately 7.7 mgd. Based on the current flow projections, the peak 20-year flow is projected to increase to 6.6 mgd by 2010 if I/I increases as projected. By 2050, the 20-year peak flow is projected to increase to 7.7 mgd. Therefore, replacing the ACP section of the force main with an 18-inch pipe would provide the required capacity through build-out.

Table 4-3: Force Main Replacement Alternatives

Alternative	Maximum Flow* (mgd)
Replace ACP with 14-inch pipe	6.6
Replace ACP with 18-inch pipe	7.7
Replace ACP with 14-inch pipe and construct parallel 14-inch force main.	8.6

*-At flows greater than the maximum flow, 175 Hp motors would be required.

If these maximum flows in Table 4-3 are exceeded, larger pump motors would be required.

As a result, either the generator will need to be replaced with a 600 kW unit or the generator would only be able to run to pumps. In addition, the size of the electrical equipment associated with the pumps, such as the VFDs, would need to be increased in size to accommodate the higher electrical loads. The larger generator would also result in higher rates of fuel consumption thereby either reducing the run time of the generator or requiring the installation of a larger underground storage tank. The construction cost to replace the existing generator and associated improvements would be roughly $280,000 versus $120,000 to replace the ACP section of the force main with an 18-inch diameter pipe instead of a 14-inch diameter pipe. For these reasons, it is recommended that the ACP section of the existing forcemain be replaced with an 18-inch diameter pipe.

Pumps, Discharge Piping, and Force Main Header

The pumps will need to be replaced to convey a peak flow of greater than 5.6 mgd. For planning purposes, it was assumed that the pump station will need to convey the 7.7 mgd, the peak 20-year storm flow at build-out. However, the pumps will still need to be replaced since the pumps will be required to convey a greater flow at a lower head compared to the existing pumps.

If the pumps are replaced to convey a peak flow of 7.7 mgd, the velocity in the suction and discharge piping would be at the upper end of standard design parameters[11, 12]. These design parameters include:

- Maximum velocity in the suction bell inlet: 3.5 fps.
- Maximum velocity in the suction piping: 5.0 to 8.0 fps.
- Maximum velocity in the discharge piping: 8.0 to 12.0 fps.

At a peak flow of 7.7 mgd, the velocity in the pump suction and discharge lines will be 7.3 fps and 11.4 fps respectively. These velocities are near the upper end of the range for standard design maximum velocities. If the suction pipes are replaced with 12-inch lines and the discharge pipes are replaced with 10-inch lines, the peak velocities will decrease to 5.0 and 7.3 fps, respectively resulting in lower headlosses. Therefore, although not absolutely necessary, replacement of the suction and discharge piping should be seriously considered with other recommended pump station improvements.

Eddy-current couplings (ECCs) control the pump speed and discharge for the existing raw sewage pump. ECCs, also commonly referred to as electric clutches, are not as energy efficient as VFDs. When the pumps are replaced to convey higher flows, the ECCs should be replaced with VFDs.

[11] Pumping Station Design, Sanks, et al., 1st Edition. (1989). Pg. 312.

[12] Pumping Station Design, Sanks, et al., 2nd Edition. (1998). Pg. 341, 361.

Wetwell Modifications

Trench type wetwells with downturned bell inlets are typically designed with a width equal to twice the diameter of the suction bell. For a 12-inch diameter suction pipe, the bell width is 19 inches. Therefore, the trench width should be increased from 30 inches to 38 inches if the suction lines are replaced. This pipe replacement will require isolation of sections of the wetwell and bypass pumping to allow for the removal of concrete to widen the wetwell and allow for the installation of concrete fillets and vortex breaking cones in the bottom of the wetwell to minimize the formation of subsurface vortices. Given the cost and difficulty of this work, further evaluation of the wetwell hydraulics is recommended. The analytical hydraulic evaluation of the wetwell by a specialist would be used to identify potential performance problems resulting from increased flows and provide recommendations to improve approach flow to the pumps. The cost for such an evaluation is approximately $10,000.

CAPITAL COSTS

Planning level costs were developed based on previous detailed cost estimates for recently constructed King County pump stations and standard cost criteria. These cost criteria include:

- A construction cost contingency of 30 percent,
- Sales tax of 8.6 percent of the estimated construction cost, and
- Allied costs of 35 percent of the total estimated capital cost.

The allied cost factor is considered to cover King County facility management, consulting services, and insurance. Detailed planning level cost estimates are included in Appendix A.

Capital costs are itemized to upgrade the pump station to 7.7 mgd, and modify the wetwell if required. The total project cost to upgrade the pump station is $2.8 million (Table 4-4). Approximately 84 percent of the cost to upgrade the pump station is associated with three items: (1) realigning and upsizing the influent sewer; (2) installing new pumps, discharge piping, and force main header; and (3) replacing the 14-inch ACP with an 18-inch pipe. The cost to modify the wetwell and increase the size of the pump suction was evaluated separately, since further evaluation may determine that these upgrades are unnecessary. The total project cost of these wetwell improvements of approximately $260,000 summarized in Table 4-5 is significantly greater than the cost of an analytical hydraulic evaluation described previously.

Table 4-4. Initial Improvements – Capital Costs

(1999 Dollars. Seattle ENRCCI=6940)

Item	Cost (Thousands)
Realign and Upsize Influent Sewer	$187
Replace Grating in the Wetwell	$11
Float Switches for the Wetwell	$15
Replace Flowmeter	$50
Electrical System Improvements	$62
HVAC System Modifications	$30
Replace Backflow Preventer	$3
Upgrade Seal Water System	$6
Underground Diesel Storage Tank	$16
Noise Attenuation	$28
New Pumps, VFDs, Control Panel, Discharge Piping, and Header	$630
Replace 14" ACP with 18-inch pipe	$428
Subtotal	**$1,474**
Contingency at 30%	$442
Subtotal	**$1,916**
Sales Tax at 8.6 %	$165
Total Estimated Capital Cost	**$2,081**
Allied Cost at 35%	$729
Total Estimated Project Cost	**$2,810**

Table 4-5. Wetwell and Suction Improvements – Capital Costs

(1999 Dollars. Seattle ENRCCI=6940)

Item	Cost (Thousands)
Pump Suction Piping	$35
Modify Wetwell to Accommodate Higher Flows	$101
Subtotal	**$136**
Contingency at 30%	$41
Subtotal	**$177**
Sales Tax at 8.6%	$15
Total Estimated Capital Cost	**$192**
Allied Cost at 35%	$68
Total Estimated Project Cost	**$260**

CHAPTER 5 – CONCLUSIONS AND RECOMMENDATIONS

In general, the Kirkland Pump Station runs well, the structure is in good condition, and equipment is readily accessible. There are a number of improvements that could be implemented to comply with code, make the pump station easier to maintain, and increase the reliability of the pump station. In addition, improvements are required to increase the pump station capacity to convey the projected future flows.

Based on the review of the existing pump station and related conveyance system components in Chapter 3, the three items with the greatest potential to disrupt pump station operations or otherwise compromise its ability to convey wastewater include:

- The influent sewer enters the wetwell above the normally operating water surface and is limited to 5.3 mgd without surcharging the line;
- The switchgear, MCCs, and associated electrical equipment are reportedly in need of replacement; and
- The capacity of the existing force main is hydraulically limited and the older ACP section have reportedly leaked.

To convey the projected increased flows and provide for a safe and reliable pump station, a number of improvements were identified in Chapter 4. Approximately 84 percent of the cost to increase the system capacity to convey the projected 20-year peak flow is associated with realigning the influent sewer, replacing the pumps and discharge piping, and replacement of the ACP section of the existing force main. These improvements are justified even if an I/I program is implemented that is sufficient to offset the projected deterioration of the collection system.

The recommended improvements are:

- Realign and upsize the influent sewer;
- Replace grating in the wetwell;
- Provide float switches in the wetwell;
- Install a new flowmeter;
- Replace electrical equipment;
- Modify the HVAC system;
- Replace the backflow preventer;

- Upgrade the seal water system;
- Install a larger capacity diesel fuel storage tank;
- Provide improved noise attenuation;
- Make aesthetic improvements to the pump station exterior;
- Replace the ACP section of the existing forcemain with 14-inch diameter pipe; and
- Replace the pumps, discharge piping, and install VFDs.

The total estimated project cost for these improvements is $2.8 million. Wetwell improvements, if further evaluation determines they are required, would add approximately $260 thousand to total project costs.